Baseline evaluation in youth ice hockey players: Comparing methods for documenting prior concussions and attention or learning disorders

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Study Design: Cross-sectional.

Objective: To examine differences in concussion history and attention or learning disorders reported by elite youth ice hockey players using a questionnaire that allows parental input compared to a clinic-based test battery that does not.

Background: A history of previous concussion and the presence of attention or learning disorders can affect concussion management decisions; however, youth athletes may not accurately report their medical history because they do not know or recall important details.

Methods: The sample included 714 (601 male, 113 female) Bantam (ages 12-14) and Midget (ages 15-17) ice hockey players from the most elite divisions of play (AA, AAA). Players completed a take-home preseason questionnaire (PSQ) with the input of a parent/guardian, then independently completed a baseline Immediate Post-Concussion Assessment and Cognitive Test (ImPACT) at the beginning of the 2011-2012 hockey season.

Results: In 21.1% (95% CI: 18.1, 24.1) of cases there was disagreement between PSQ and ImPACT in the number of previous concussions reported. For those reporting an attention disorder on the PSQ, 85.7% also reported it on ImPACT. Only 9.5% of those who reported a learning disorder on the PSQ also reported it on ImPACT.

Conclusion: For 1 in 5 players, reported concussion history differed between PSQ and ImPACT, and there was substantial disagreement between instruments

for those reporting learning disorders. The method of obtaining medical history may therefore affect baseline and post-concussion evaluations.

Key Words: Baseline testing; medical history; youth sport

Concussion is a common injury among youth athletes, with the highest rates reported in contact sports such as ice hockey.[1,11,13,21,23] Defined as a complex pathophysiological process affecting the brain induced by traumatic biomechanical forces ,[28-29] concussion is an evolving heterogeneous injury. Clinical findings of this multifaceted injury may include somatic and/or emotional symptoms, physical signs, behavioral changes, cognitive impairment, and/or sleep disturbances.[28-29] Baseline evaluations may enhance a clinician's ability to diagnose, manage, and monitor the trajectory of recovery for athletes following concussion.

Baseline evaluations commonly include a demographic and injury history section, along with assessments of neurocognitive function, motor function, and/or symptoms.[5,13,19] Traditionally, baseline medical information has been recorded using paper and pencil methods and, for youth athletes, parental input is often permitted during questionnaire completion.[11,13] Importantly, medical history may not be known, recalled, or understood by youth, resulting in an under-representation of conditions that can influence clinical evaluations when the athlete does not have the benefit of parental oversight. This is of particular concern with the increasing popularity of computerized testing, which does not allow for parental assistance (i.e., the athlete completes this information on his/her own just prior to participating in the testing). Thus, depending on the setting and nature of data collection, there may be variability in the information collected from youth athletes.

The Immediate Post-Concussion Assessment and Cognitive Test (ImPACT) is a popular web-based, computer-administered neuropsychological test battery used for baseline and post-concussion evaluation.[18-19,24,35] A demographic information portion is completed at the start of each test, and includes items such as age, previous history of concussion, number of previous concussions, and previous diagnosis of an attention or learning disorder. Research has shown that the results of baseline cognitive tests can be affected by a history of learning and attention disorders.[6,26] Specifically, results from tests of verbal learning, working memory, complex attention, and processing speed are most sensitive to these conditions.[6,26] The accuracy of baseline information, particularly related to medical history, is therefore essential when interpreting test results and for the validity of clinical assessments.

It is necessary to consider, however, that children and adolescents may be more sensitive to the mode of questionnaire administration than adults.[40] For example, the current literature suggests that mode of symptom reporting has been found to affect the number and intensity of concussion symptoms reported by athletes.[22] The issue of social desirability bias must also be considered when discussing self-report of attention deficits or learning disabilities. Youth athletes may under report these conditions to avoid embarrassment or to project a more favorable image to others.[3] This issue may be particularly salient when athletes are being tested in a team setting,[32] although its effect on responses to the ImPACT demographic questions is unknown.

Moreover, there is considerable evidence that concussions are under-reported by young athletes.[27,38-39] This has largely been attributed to poor understanding of the signs, symptoms, and potential long-term sequelae of concussion or deferring medical history knowledge to parents, and has been combatted with education-based interventions.[9,34,37-38] Because a previous concussion is one of the strongest predictors of future concussions,[12-13] it is possible that athletes will under-report previous concussions to avoid being labeled as "high risk" or being advised to discontinue sport participation.

The extent to which self-report of previous history of concussion, attention disorders, or learning disorders may differ between a paper baseline questionnaire and the ImPACT background history section is unknown. Therefore, the primary objective of this study was to examine the differences in concussion history, attention disorders, and learning disorders reported by elite youth ice hockey players using a paper-based questionnaire that allows parental input compared to ImPACT, which does not allow parental input. The secondary objective was to determine the effect of age group and sex on agreement between the 2 methods.

METHODS

Study design and participants

This validation study used cross-sectional data that were collected during the baseline assessment phase of a larger prospective cohort study conducted in

the 2011-2012 ice hockey season.[4] The study population was Bantam (ages 13-14) and Midget (ages 15-17) ice hockey players competing in the most elite divisions (AA, AAA) in Calgary and Edmonton, Canada. Players were required to be 13-17 years at the end of the calendar year to participate on a team in 1 of these age groups, but some Bantam players were 12 years of age at the time of baseline assessment. Similarly, some Midget players were 14 years of age at baseline. Inclusion criteria were the following: male or female players; aged 12-17 through the season of play; written informed consent to participate (player and 1 parent or guardian); players registered with Hockey Calgary, Girls Hockey Calgary, Edmonton Minor Hockey Association, or the Edge School (Calgary); players participating in the Bantam or Midget age groups only; players in elite divisions of play (AA, AAA); agreement of the player's head coach to participate in the study; and agreement of the team therapist to collect information about individual player participation and injury throughout the season as part of the larger cohort study. Players were excluded if they had sustained a previous injury or chronic illness that prevented full participation in hockey at the beginning of the 2011-2012 season.

Approval for this study was granted by the research ethics boards at the University of Calgary and the University of Alberta.

Data collection

Consent forms and Preseason Questionnaires were distributed to all participants 2-3 weeks prior to baseline testing. These were completed at home,

with instructions that the questionnaire was to be completed with the assistance of a parent or guardian, and submitted at the baseline testing session. Baseline testing was conducted, by team, at the University of Calgary Sport Medicine Centre, the Glen Sather Sport Medicine Clinic in Edmonton, or LifeMark Physiotherapy at the Edge School. At these sessions, players completed ImPACT on individual laptop computers with an external mouse under the supervision of a research assistant. Up to 10 players completed ImPACT simultaneously, and the testing environment was kept as quiet and free from distractions as possible.

Outcome measures

The Preseason Questionnaire (PSQ) is part of a previously validated injury surveillance system,[11,13] and was designed to pre-screen athletes at baseline for medical, mental health, or behavioral conditions. It is a paper-and-pencil instrument that collects information regarding participant demographics (ie: age, sex, height, weight), current sport participation, protective equipment worn during hockey participation, and previous medical history (ie: injury history, surgical history, diagnosed medical conditions). The questionnaire asks specifically about previous concussions ("Have you ever had a concussion or been 'knocked out' or had your 'bell rung'?") as well as attention deficits and learning disabilities ("Have you ever been formally diagnosed by a health care professional (physician, psychologist, etc.) as having an attention or learning

issue?"). The PSQ was sent home with the study consent form, with instructions that it was to be completed with parental input.

The ImPACT battery is a web-based computer-administered neuropsychological test.[18-19,24,35] It was developed for the acute assessment of sports-related concussion in youth, collegiate, and professional athletes, and was designed to minimize practice effects through the use of several alternating forms. ImPACT yields 5 composite scores for visual memory, verbal memory, visual motor processing speed, reaction time, and impulse control, and also provides a total symptom score from the post-concussion symptom inventory. Prior to starting the cognitive testing with ImPACT, the athlete completes a number of sport- and health-related questions, including questions that ask the athlete to identify the number of prior concussions they have experienced (i.e., "Indicate number of times diagnosed with a concussion") and whether they have any attention or learning disorders ("Check if the following apply: diagnosed attention deficit disorder or hyperactivity; diagnosed learning disability"). The ImPACT battery takes approximately 30 minutes to complete, including the background questions, and the athlete completes it without parental input.

Although the PSQ and ImPACT have been used in previous injury surveillance studies,[11,13,18-19,24,35] the validity and reliability of their demographic and medical history questions have not been previously established in the literature.

Analysis

Stata version 12.0 was used for all statistical analyses. Descriptive statistics are reported as frequencies, proportions with 95% confidence intervals, or medians with ranges. Agreement in the number of concussions and the presence of attention or learning disorders reported using the PSQ and the ImPACT test was examined using intraclass correlation coefficients (ICC). Models [ICC(3,1)] were fit using a repeated measures design to account for multiple scores given from individual raters. A multivariable logistic regression model, adjusted for cluster by team, was fit to assess the effect of age group (Bantam or Midget) and sex (male or female) on agreement (yes/no) in concussion history between the PSQ and ImPACT.

RESULTS

Of the 742 participants who were recruited for the larger cohort study, 714 (96.2%) completed both the PSQ and baseline ImPACT testing and are therefore included in the present analysis. Baseline characteristics of included players are presented in **TABLE 1**.

The proportion of players reporting a concussion, attention disorder, or learning disorder using the PSQ and ImPACT are reported in **TABLE 2**. Overall agreement between PSQ and ImPACT for history of any prior concussion was moderate (ICC = 0.69), but it was substantially poorer for those reporting 1 previous concussion (ICC = 0.53). Agreement for reported attention disorders

(ICC = 0.95) and learning disorders (ICC = 0.94) across the entire sample was very good.

Prevalence rates for disagreement in the number of previous concussions reported on the PSQ compared to ImPACT is shown in **TABLE 3**. Overall, there was disagreement between PSQ and ImPACT in 21.1% (95% CI: 18.1, 24.1) of cases. Compared to the PSQ, ImPACT indicated fewer concussions in 9.6% (95% CI: 7.4, 11.8) of cases and more concussions in 11.4% (95% CI: 9.1, 13.8) of cases. Disagreement was highest for those reporting 1 (41.3%) or 2 (38.7%) previous concussions.

When examining self-reported history of previous concussions, Bantam players were less likely to have agreement (odds ratio [OR] = 0.53; 95% CI: 0.35, 0.80) between the PSQ and ImPACT than Midget players, adjusting for cluster by team. There was no trend in favor of either instrument for the Bantam players. There was no association between sex and agreement (males compared to females: OR = 0.85; 95% CI: 0.45, 1.59).

Congruence between the PSQ and ImPACT regarding reported attention and learning disorders is presented in **TABLE 4**. Overall, there was agreement between PSQ and ImPACT in the vast majority (96.0%) of cases, with most players reporting no attention or learning problems on either instrument. Of those reporting an attention disorder on the PSQ (n = 14), 85.7% also reported a

problem on ImPACT. However, 90.5% of those who reported a learning disorder on the PSQ (n = 21) did not report it on ImPACT.

DISCUSSION

In our comparison of the PSQ and ImPACT, we found notable disagreement in self-reported learning problems and concussion history. Although our results may reflect differences that existed due to the amount of parental input given when completing the PSQ, it is likely that few players completed the PSQ independently, given their age and the detailed nature of the questions. As per the instructions, the majority of players likely had at least some parental input or the parents completed the PSQ on behalf of the player. Interpretation of the results is therefore framed to reflect PSQ responses that included parental input.

The largest disagreements in concussion history existed for those reporting 1 or 2 previous concussions, and more of those players reported fewer concussions on ImPACT compared to the PSQ. It is possible that parental input may have resulted in a more sensitive self-reported history, particularly for those with a small number of previous concussions. Parents may have more precise recollection or record of previous injuries, or they may consider some injuries to be concussions while players do not. For example, parents may use a broader definition of concussion and include incidents where the player was not medically diagnosed but had observable symptoms, whereas players may not believe that

these events constitute a concussion.[14] Considering the high number of players who had a larger estimate of their concussion history on ImPACT compared to the PSQ, however, it is equally probable that players included on-ice events that their parents were unaware of because they were not formally diagnosed as concussions. There is some evidence that children and parents have only low-to-moderate agreement in symptom reporting following concussion,[14] congruent with studies in the domains of psychology and quality of life research suggesting that children often report more somatic symptoms[11,16] while parents report more cognitive or behavioral symptoms.[11,16] This may have influenced whether parents or athletes considered a particular event to be a concussion. These alternative explanations may indicate important differences in the level of concussion awareness among elite youth ice hockey players and their parents, which warrant further research and player/parent education considerations.

Moreover, there is evidence that the wording of questions can influence the quality of information elicited from respondents. Using very specific items and providing comprehensive response options has been shown to stimulate recall for health-related events.[8] Because the PSQ provides a broader range of terms used to identify concussion (i.e.: “Have you ever had a concussion or been ‘knocked out’ or had your ‘bell rung’?”) than ImPACT, which specifically asks about the number of times an individual has been *diagnosed* with a concussion, responses to the PSQ would likely capture a more sensitive picture of previous concussion events. This has implications in terms of the type of concussion history obtained through ImPACT (e.g., “diagnosed” concussions only), and may

indicate the need to collect a more comprehensive injury history during baseline and post-concussion evaluations.

Under circumstances where there is particular public attention to a health issue, recall can be more accurate for the condition of concern than other related health matters.[17] Considering recent publicity and awareness campaigns directed at sport concussion, it is likely that parents and players demonstrated enhanced recall for concussion events in the present study. It is assumed that parents and players completed the PSQ together, as instructed. Differential recall between PSQ and ImPACT is therefore unlikely, given the short time frame between administration of the 2 questionnaires, unless parents completed the PSQ without player input. Discrepancies between the PSQ and ImPACT may therefore be attributed to other sources of error, such as recall bias related to the timing of concussion events, or even differences in the medium in which questions were presented (computer versus pencil and paper).

Although all self-report measures are vulnerable to recall bias, concussion history may be particularly sensitive to the length of the recall period. In a seminal study, Harel and colleagues[15] found that parents have diminishing recall of their children's injuries over time, particularly those injuries that did not require medical attention or result in time loss from school. In the present study, concussions occurring months or years previously may therefore have been underreported, especially if medical attention was not sought. Harel et al[15] also demonstrated that recall for injuries sustained by adolescent (age 14-17 years) boys appears to have a sharper decrease over time than for adolescent girls, for

whom recall remains relatively stable. For children 13 years and younger, they reported a similar steady decrease in recall over time for both sexes.[15] This supports our finding that Bantam players were more likely to have disagreement in their concussion history than Midget players, though we were unable to replicate sex-specific differences. Due to the relatively small sample of female players in our study we may have been underpowered to detect this relationship, or elite level female athletes may demonstrate similar sport-specific injury recall to their male counterparts and therefore have equivalent discrepancies in self-reported concussion history.

Social desirability bias is another potential source of error between PSQ and ImPACT. It has been suggested that youth athletes may under-report medical conditions to project a more favorable image to others, particularly in a team setting.[3,32] The high proportion of athletes reporting more concussions on ImPACT compared to the PSQ indicates that this did not affect concussion reporting in this sample. With changing attitudes in the sport community, there is decreasing stigma associated with having sustained a concussion and, as a result, athletes are likely more willing to be transparent about their concussion history.

Similarly, with increased public acceptance of attention problems such as Attention Deficit Hyperactivity Disorder (ADHD),[30] adolescents may be more willing to report being diagnosed with one of these conditions. The congruence between PSQ and ImPACT reports of attention disorders support this, although it is interesting that a small proportion (1.5%) of players did not report an attention

disorder on PSQ but reported one on ImPACT. This suggests that not only are these players comfortable reporting attention problems in team settings, they may report problems that have not been formally diagnosed or that they are unwilling to report using a take-home questionnaire. Although these findings pertain to a very small proportion of our sample, it may point to a valuable area for future research.

The proportion of athletes who did not report a learning difficulty on ImPACT despite a positive response on the PSQ, however, may be evidence of social desirability bias. Although only a small percentage (3.2%) of our total sample reported a learning difficulty on PSQ, 90.5% of those players did not report it on ImPACT. The stigma associated with learning difficulties,[36] particularly in school-aged children, may have influenced responses on ImPACT because it was administered in a group setting.[7,20,25,31] As learning difficulties have the potential to affect tests of cognitive ability, the method by which adolescents are asked to report their disabilities should be carefully considered, given these results.[6,26]

From a clinical perspective, the importance of an accurate concussion history during neurocognitive testing can be debated. Studies have ranged from finding no residual cognitive deficits in children and adolescents following concussion[2,4] to reporting significant lingering effects of prior concussion.[33] Minor discrepancies between a paper-and-pencil medical questionnaire and ImPACT may therefore be negligible in terms of concussion management. Yet, for the roughly 13% of players in this study who reported no history of concussion using

one instrument and at least 1 concussion on the other, there may be implications for injury prevention. Because having 1 concussion is a significant predictor of future concussions,[12-13] it is important for baseline evaluations to be accurate to allow for the most accurate baseline concussion risk assessment.

From a clinical standpoint, individuals with a history of multiple concussions may be managed in a more conservative nature than an athlete with a history of 1 concussion. Additionally, clinical monitoring for concussion may be greater in individuals with a greater number of reported previous concussions and result in more conservative management in the event of a suspected concussion. In this study, disagreement in reported number of concussions was greatest for individuals reporting 1 or 2 previous concussions. Thus, depending on the methods of reporting concussions an individual may be monitored more or less closely for future concussion. Future studies to compare the number of concussions reported on the PSQ and ImPACT compared with a clinical interview would be of benefit.

Differences in self-reported learning difficulties also have the potential to significantly affect baseline and post-concussion evaluations.[6,26] As such, the PSQ or a similar take-home background questionnaire may be preferable to the medical history portion of ImPACT.

Limitations

Although standardized forms were used to collect the preseason baseline data, it is not known how much input parents had when completing the PSQ. In

some cases, parents may have completed the majority of the questionnaire and may have a more accurate recollection/record of the medical history of their child. Individuals who completed the questionnaire with limited parental input may have been more likely to report the same score on repeat questioning. Alternatively, the participants whose parents completed the entire questionnaire may have not known the parental answers to some of the questions, resulting in interrater variability rather than intrarater variability, as well as unknown measurement bias.

Future directions

Considering the potential clinical implications of previous concussion history, attention disorders, and learning disorders, it will be important to determine the most valid method of collecting medical history information during concussion assessment. Future studies examining the validity of both paper and computerized self-report approaches are necessary to advance best practice standards in concussion management.

CONCLUSION

There are sizable discrepancies in self-reported concussion history and learning disorders between the take-home PSQ and the computerized ImPACT test, which may be due to the amount of parental input permitted using the PSQ method. Although differences in how concussion history is documented do not appear to systematically over- or under-estimate the number of previous

concussions, there is a tendency to report fewer learning disorders on ImPACT. Clearly, *how* an athlete is asked to document his or her past history makes a difference on the answers obtained. Researchers and clinicians should account for these differences when evaluating youth athletes, but future studies are needed to determine the validity of both paper and computerized methods of obtaining medical history information.

KEY POINTS

Findings: Youth ice hockey players reported their concussion history and learning disorders differently using a take-home medical questionnaire compared to ImPACT. The number of previous concussions did not appear to be systematically higher or lower using either reporting method, but there was a bias toward underreporting learning difficulties on ImPACT.

Implications: The interpretation of post-concussion assessments may be influenced by the method of obtaining medical history. Researchers and clinicians should consider parental input when assessing youth athletes, and must be aware of potential biases in self-reported learning disorders.

Caution: It is unclear whether a take-home questionnaire that allows parental input is more accurate than the ImPACT demographic questions. The validity of both of these methods compared to medical records is unknown.

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	Males (n = 601) Frequency (%) or Median (range)	**Females (n = 113)** Frequency (%) or Median (range)
Age	15 (12-17)	15 (13-17)
Age group		
Bantam (ages 12-14)	166 (27.6)	50 (44.3)
Midget (ages 14-17)	435 (72.4)	63 (55.8)
Competitive level		
AAA	339 (56.4)	113 (100.0)
AA	262 (43.6)	-

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528 Table 1. Participant characteristics.

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	PSQ (95% CI)	ImPACT (95% CI)	ICC (95% CI)
Percentage reporting a previous concussion (yes/no)	41.2 (37.6, 44.8)	36.4 (32.9, 39.9)	0.69 (0.10, 1.00)
1 previous concussion	32.9 (29.5, 36.4)	23.7 (20.6, 26.8)	0.53 (0, 1.00)
2 previous concussions	6.2 (4.4, 7.9)	9.2 (7.1, 11.4)	0.70 (0.11, 1.00)
3 or more previous concussions	1.3 (0.4, 2.1)	3.5 (2.2, 4.9)	0.76 (0.26, 1.00)
Proportion missing	0.8 (0.2, 1.5)	-	-
Percentage reporting attention problems	2.0 (0.9, 3.0)	3.2 (1.9, 4.5)	0.95 (0.82, 1.00)
Proportion missing	0.3 (0, 0.7)	2.1 (1.1, 3.2)	-
Percentage reporting learning difficulties	2.9 (1.7, 4.2)	0.3 (0, 0.7)	0.94 (0.78, 1.00)
Proportion missing	4.9 (3.3, 6.5)	2.9 (1.7, 4.2)	-

Table 2. Players reporting previous concussion, attention problem, or learning difficulty at baseline.

	PSQ concussions (Frequency)			
ImPACT concussions (Frequency)	**0**	**1**	**2**	**3 or more**
0	387	57	4	1
1	25	138	5	1
2	5	33	27	-
3 or more	3	7	8	7

Table 3. Disagreement in PSQ and ImPACT report by number of previous concussions.

	PSQ (Frequency)	
ImPACT (Frequency)	No	Yes
Attention problem		
No	672	2
Yes	11	12
Learning difficulty		
No	644	19
Yes	0	2

Table 4. Comparison between PSQ and ImPACT reports of attention problems and learning difficulties.